Clause	Header	Presence	Constraints
6.8.3	DCEP-address parameters	YES	–
6.8.4	User data	YES	–
6.8.5	Sending and receiving RAS DLPDU	YES	Relevant feature to star-architecture
6.9	Loop repeat request DLPDU (LRR)	NO	–
6.10	Loop diagnosis DLPDU (LPD)	NO	–

12.2.3 Application layer

12.2.3.1 AL service selection

Table 155 specifies the AL service selection within IEC 61158-5-11.

In addition AL services are mapped onto the TCP/UDP/IP protocol suite, as defined in RFC 793, RFC 768 and RFC 791 respectively.

Table 155 – CP 11/1: AL service selection

Clause	Header	Presence	Constraints
1	Scope	YES	–
2	Normative references	YES	Relevant reference only
3	Terms and definitions, abbreviations and conventions	Partial	Used when applicable
4	Concepts	YES	–
5	Data type ASE	Partial	Used when applicable
6	Communication model specification	YES	–

12.2.3.2 AL protocol selection

Table 156 specifies the AL protocol selection within IEC 61158-6-11.

Table 156 – CP 11/1: AL protocol selection

Clause	Header	Presence	Constraints
1	Scope	YES	–
2	Normative references	Partial	Relevant reference only
3	Terms, definitions, symbols, abbreviations and conventions	Partial	Used when applicable
4	FAL Syntax description	YES	–
5	Transfer syntax	YES	–
6	FAL protocol state machine structures	YES	–
7	FAL Service Protocol Machine (FSPM)	YES	–
8	Application Relationship Protocol Machines (ARPM)	YES	–
9	DLL Mapping Protocol Machines (DMPM)	YES	–

12.2.4 Performance indicator selection

12.2.4.1 Performance indicator overview

Table 157 shows the performance indicators overview of CP 11/1.

Table 157 – CP 11/1: PI overview

Performance indicator	Applicable	Constraints
Delivery time	YES	–
Number of end-stations	YES	–
Basic network topology	YES	Star topology
Number of switches between end-stations	NO	Hubs fit, and switches should not be applicable for highest performance
Throughput RTE	YES	–
Non-RTE bandwidth	YES	–
Time synchronization accuracy	YES	IEC 61588 shall be installed
Non-time-based synchronization accuracy	YES	–
Redundancy recovery time	YES	Null time switching without interruption

12.2.4.2 Performance indicator dependencies

12.2.4.2.1 Dependency matrix

Table 158 shows the dependencies between performance indicators for CP 11/1.

Table 158 – CP 11/1: PI dependency matrix

Dependent PI	Influencing PI							
	Delivery time	Number of end-stations	Basic network topology	Throughput RTE	Non-RTE bandwidth	Time synchronization accuracy	Non time- based synchronization accuracy	Redundancy recovery time
Delivery time		NO 12.2.4.2.2 12.2.4.2.4	NO 12.2.4.2.5	NO 12.2.4.2.2 12.2.4.2.3	NO 12.2.4.2.2 12.2.4.2.3	NO	NO	NO 12.2.4.2.6
Number of end-stations	NO		NO	YES 12.2.4.2.2 12.2.4.2.3	YES 12.2.4.2.2 12.2.4.2.3	NO	NO	NO
Basic network topology	NO	NO		NO	NO	NO	NO	NO
Throughput RTE	YES 12.2.4.2.2 12.2.4.2.3	YES 12.2.4.2.2 12.2.4.2.3	NO		YES 12.2.4.2.2 12.2.4.2.3	NO	NO	NO
Non-RTE bandwidth	YES 12.2.4.2.2 12.2.4.2.3	YES 12.2.4.2.2 12.2.4.2.3	NO	YES 12.2.4.2.2 12.2.4.2.3		NO	NO	NO
Time synchronization accuracy	NO	NO	NO	NO	NO		NO	NO
Non-time-based synchronization accuracy	NO	NO	NO	NO	NO	NO		NO
Redundancy recovery time	NO	NO	NO	NO	NO	NO	NO	

12.2.4.2.2 Calculation of Delivery time

Delivery time is definitely specified by the application users using the TCC data service, and the delivery time specified meets both cases of no transmission error and one lost frame with recovery.

The TCC data service provides 3 kinds of the data transmission service at the same time, that are according to the data preference and the delivery time of an APDU to be transferred using the data transmission service.

Table 159 specifies the TCC data service selection supported by this profile.

Table 159 – CP 11/1: TCC data service selection

Service ref.	Service name	Applicable	Constraint
IEC 61158-3-11 Clause 4	High-speed cyclic data transmission	YES	The range of the high-speed transmission period (T_h) is 1 ms to 160 ms, of which unit is in 0,1 ms
IEC 61158-3-11 Clause 4	Medium-speed cyclic data transmission	YES	The range of the medium-speed transmission period (T_m) is 10 ms to 1 000 ms, of which unit is in 1 ms and in multiples of the T_h
IEC 61158-3-11 Clause 4	Low-speed cyclic data transmission	YES	The range of low-speed transmission period (T_l) is 100 ms to 10 000 ms, of which unit is in 1 ms and in multiples of the T_h

The performance indicator delivery time is related to the amount of both RTE data and non-RTE data which are exchanged between the end-stations, the number of the Ethernet frame that is used for the deterministic transmission scheduling, the signal propagation delay to the end-station, the number of the end-stations and the number of the Hubs between the end-stations.

The performance indicator delivery time can be calculated using the Formulae (29), (30), (31), (32) and (33).

$$DT_H = T_h \quad (29)$$

$$DT_M = T_m \quad (30)$$

$$DT_L = T_l \quad (31)$$

$$T_h = T_{RTE} + T_{NRT} + T_{SCH} + T_{PD} + T_{MAC} \quad (32)$$

$$T_{RTE} = T_{HS} + \frac{T_{MS}}{T_m} \times T_h + \frac{T_{LS}}{T_l} \times T_h \quad (33)$$

where

DT_H is the delivery time for the high-speed cyclic data, which includes both the sender stack traversal time (STTs) and the receiver stack traversal time (STTr) including Phy and MAC;

DT_M is the delivery time for the medium-speed cyclic data, which includes both the sender stack traversal time (STTs) and the receiver stack traversal time (STTr) including Phy and MAC;

DT_L is the delivery time for the low-speed cyclic data, which includes both the sender stack traversal time (STTs) and the receiver stack traversal time (STTr) including Phy and MAC;

T_h is the high-speed transmission time period, and is the basic cycle_time (ct) for the TCC data service;

T_m is the medium-speed transmission time period;

T_l is the low-speed transmission time period;

T_{RTE} is the total sum of the frame transmit time, in which the frame of the Ethernet with the RTE data as a payload of a fixed length is sent out of the end-station within the time period of T_h. The total volume of the RTE data and the bandwidth for the non-RTE data is specified by the application user;

T_{NRT} is the total sum of the frame transmit time, in which the frame with the non-RTE data as a payload is sent out of the end-station within the time period of T_h and is used for the standard Ethernet application on sporadic basis;

T_{SCH} is the total sum of the frame transmit time, in which the frame is exchanged for the deterministic transmission scheduling between the end-stations. The T_{SCH} includes both the time for the synchronization DLPDU and the multiple Transmission complete DLPDUs which are specified in the IEC 61158-4-11, Clause 6;

T_{PD} is the sum total of the signal propagation delay (pd) between the end-stations. The T_{PD} depends on the number of Hubs between the end-stations, the cable propagation delay (cd) and the number of the end-stations;

T_{MAC} is the time for the maintenance and control, in which a new end-station is solicited to join and the periodic time operation is controlled;

T_{HS} is the total sum of the frame transmit time, in which the TCC data frame conveys the high-speed cyclic data;

T_{MS} is the total sum of the frame transmit time, in which the TCC data frame conveys the medium-speed cyclic data;

T_{LS} is the total sum of the frame transmit time, in which the TCC data frame conveys the low-speed cyclic data.

12.2.4.2.3 Relation between throughput RTE and non-RTE bandwidth

Figure 9 shows an example of the relation between the throughput RTE and the non-RTE bandwidth in the case of 100 Mbit/s physical layer. This profile supports the specification of a percentage of the bandwidth and/or the throughput which are used for the non-RTE and the RTE communications.

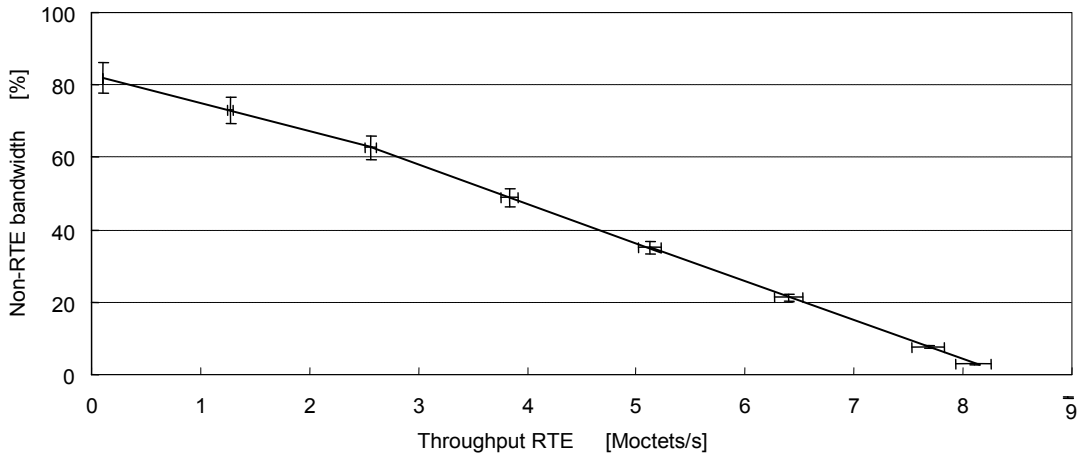

Figure 9 – CP 11/1: Throughput RTE and non-RTE bandwidth

The throughput RTE indicates the total amount of the APDU data by octet length per second, and the APDU data is sent out by the node using the TCC data service specified in the IEC 61158-3-11, 4.3. The non-RTE bandwidth indicates the total percentage of the bandwidth, which is used for the non-RTE communications by the nodes using the sporadic message data service specified in the IEC 61158-3-11, 4.4.

The total bandwidth can be calculated using the Formulae (34), (35), (36), (37), (38) and (39).

$$BW = BW_{RTE} + BW_{NRT} + BW_{CNT} \tag{34}$$

$$BW_{RTE} = TR_{RTE} \times \frac{8}{100} \tag{35}$$

$$TR_{RTE} = TR_{HS} + TR_{MS} + TR_{LS} \tag{36}$$

$$TR_{HS} = \frac{DV_{HS}}{DT_H} \tag{37}$$

$$TR_{MS} = \frac{DV_{MS}}{DT_M} \tag{38}$$

$$TR_{LS} = \frac{DV_{LS}}{DT_L} \tag{39}$$

where

BW	is the total bandwidth in %, and the 100 % is 100 Mbit/s;
BW_{RTE}	is the bandwidth used for the RTE communications in %;
BW_{NRT}	is the bandwidth used for the non-RTE communications in %;
BW_{CNT}	is the bandwidth used for the scheduling communications and for the protocol overhead in %;
TR_{RTE}	is the throughput RTE in Moctets/s;
TR_{HS}	is the throughput RTE for the high-speed cyclic data in Moctets/s;
TR_{MS}	is the throughput RTE for the medium-speed cyclic data in Moctets/s;
TR_{LS}	is the throughput RTE for the low-speed cyclic data in Moctets/s;
DV_{HS}	is the total volume of the high-speed cyclic data sent by all end-stations;
DV_{MS}	is the total volume of the medium-speed cyclic data sent by all end-stations;
DV_{LS}	is the total volume of the low-speed cyclic data sent by all end-stations;
DT_{H}	is the delivery time for the high-speed cyclic data, which includes both the sender stack traversal time (STTs) and the receiver stack traversal time (STTr) including Phy and MAC;
DT_{M}	is the delivery time for the medium-speed cyclic data, which includes both the sender stack traversal time (STTs) and the receiver stack traversal time (STTr) including Phy and MAC;
DT_{L}	is the delivery time for the low-speed cyclic data, which includes both the sender stack traversal time (STTs) and the receiver stack traversal time (STTr) including Phy and MAC.

The throughput RTE or the non-RTE bandwidth depends on the BW_{CNT} for scheduling the communications and for the protocol overhead. The scheduling communications and the protocol overhead, based on the formulas provided in 12.2.4.2.2, depend on the number of the hubs between the end-stations, the cable propagation delay and the total number of the end-stations, and is related to the time for the maintenance and control in order to solicit a new end-stations and to keep the periodic time operation.

12.2.4.2.4 Number of end-stations

The maximum number of the end-stations shall be up to 254.

12.2.4.2.5 Basic network topology

The network topology supported by this profile is of a hierarchical star. The number of layers in a hierarchy is an application specific and is determined on the basis of the number of end-stations, their physical location, and the distance between the end-stations. The maximum number of hubs between any 2 end-stations shall be up to 7.

12.2.4.2.6 Redundancy recovery time

The maximum time from a failure to become fully operational again in case of a single permanent failure is almost 0 time period. This profile supports fully operational without the interruption of the higher-level data transfer services.

12.2.4.3 Consistent set of performance indicators

12.2.4.3.1 Consistent set of PIs preferential for RTE communications

Table 160 shows one of a consistent set of the performance indicators for CP 11/1. The values in Table 160 are representing one of the practical example, but not of the theoretical maximum, and the example is preferential for the RTE communications, which means that the total available bandwidth both for the RTE communications and the non-RTE communications is allocated alone to the RTE communications.

Table 160 – CP 11/1: Consistent set of PIs preferential for RTE communications

Performance indicator	Value	Constraints
Delivery time	DT_H = 2 ms DT_M = 20 ms DT_L = 200 ms	–
Number of end-stations	24	Maximum distance between nodes is 4 km
Number of switches between end-stations	0	3 hubs
Throughput RTE	Total = 7,3 Moctets/s TR_{HS} = 6,4 Moctets/s TR_{MS} = 0,9 Moctets/s	DV_{HS} = 12 800 octets DV_{MS} = 19 200 octets DV_L = 0 octets
Non-RTE bandwidth	0 %	–
Non-time-based synchronization accuracy	< 10 µs	–
Redundancy recovery time	0 s	–

12.2.4.3.2 Consistent set of PIs for RTE and non-RTE communications

Table 161 shows one consistent set of performance indicators for CP 11/1. The values given in Table 161 are representing one practical example, but they are not the theoretical maximum. The total available bandwidth is partitioned between the RTE communications and the non-RTE communications.

Table 161 – CP 11/1: Consistent set of PIs both for RTE and non-RTE communications

Performance indicator	Value	Constraints
Delivery time	DT_H = 2 ms DT_M = 20 ms DT_L = 200 ms	–
Number of end-stations	13	Maximum distance between nodes is 4 km
Number of switches between end-stations	0	5 hubs
Throughput RTE	Total = 5,7 Moctets/s TR_{HS} = 5,1 Moctets/s TR_{MS} = 0,6 Moctets/s	DV_{HS} = 10 240 octets DV_{MS} = 12 800 octets DV_L = 0 octets
Non-RTE bandwidth	< 20 %	–
Non-time-based synchronization accuracy	< 10 µs	–
Redundancy recovery time	0 s	–

12.3 Profile 11/2

12.3.1 Physical layer

The physical layer of 100 Mbit/s shall be according to ISO/IEC/IEEE 8802-3.

Connectors and cables are specified in IEC 61784-5-11 and IEC 61918.

12.3.2 Data-link layer

12.3.2.1 DLL services selection

The DLL service selection is the same as specified in 12.2.2.1.

12.3.2.2 DLL protocol selection

Table 162 specifies the DLL protocol selection within IEC 61158-4-11.

Table 162 – CP 11/2: DLL protocol selection

Clause	Header	Presence	Constraints
1	Scope	YES	–
2	Normative references	YES	Relevant reference only
3	Terms, definitions, symbols and abbreviations	Partial	–
4	Overview of the DL-protocol	–	–
4.1	General	YES	–
4.2	Overview of the medium access control	YES	–
4.3	Service assumed from the PhL	YES	–
4.4	DLL architecture	–	–
4.4.1	Overview	YES	–
4.4.2	Star-architecture	NO	–
4.4.3	Loop-architecture	YES	–
4.5	Access control machine and schedule support functions	YES	–
4.6	Local parameters, variables, counters, timers and queues	–	–
4.6.1	Overview	YES	–
4.6.1.1	General	YES	–
4.6.1.2	Summary of variables, parameters, counters, timers for star-architecture	NO	–
4.6.1.3	Summary of variables, parameters, counters, timers for loop-architecture	YES	Relevant values and features to 100 Mbit/s data rate
4.6.2	Type 11 common variables, parameters, counters, timers and queues	YES	Relevant values and features to 100 Mbit/s data rate
4.6.3	Star-architecture specific variables, parameters, counters timers and queues	NO	–
4.6.4	Loop-architecture specific variables, parameters, counters timers and queues	YES	Relevant values and features to 100 Mbit/s data rate

Clause	Header	Presence	Constraints
5	General structure and encoding of PhIDEs and DLPDU and related element of procedure	YES	See Table 163
6	DLPDU-specific structure, encoding and elements of procedure	YES	See Table 164
7	DLE element of procedure	–	–
7.1	DLE elements of procedure for star-architecture	NO	–
7.2	DLE elements of procedure for loop-architecture	–	–
7.2.1	Overall structure	YES	–
7.2.2	Initialization	YES	–
7.2.3	Cyclic transmission TX/RX control (CTRC)	YES	Relevant values and features to 100 Mbit/s data rate
7.2.4	Sporadic TX/RX control (STRC)	YES	–
7.2.5	Access control machine (ACM)	YES	Table 75 applicable
7.2.6	Redundancy medium control (RMC)	YES	Table 83 applicable
7.3	Serializer and deserializer	YES	–
7.4	DLL management protocol	–	–
7.4.1	DLL management protocol for star-architecture	NO	–
7.4.2	DLL management protocol for loop-architecture	YES	–

Table 163 – CP 11/2: DLL protocol selection of Clause 5

Clause	Header	Presence	Constraints
5.1	Overview	YES	–
5.2	PhIDU structure and encoding	YES	–
5.3	Common MAC frame structure, encoding and elements of procedure	YES	–
5.4	Elements of the MAC frame	–	–
5.4.1	General	YES	–
5.4.2	Preamble field	YES	–
5.4.3	Start frame delimiter (SFD)	YES	–
5.4.4	Address field	YES	–
5.4.5	Length/type field	YES	–
5.4.6	Frame control field (FC)	–	–
5.4.6.1	Structure of FC field	YES	–
5.4.6.2	Frame type (F-type) field	YES	–
5.4.6.3	Priority field (Pri)	YES	Relevant feature to 100 Mbit/s data rate
5.4.7	Source node number field (SN)	YES	–
5.4.8	Data and pad field	YES	–
5.4.9	Frame check sequence (FCS)	YES	–
5.5	Order of bit transmission	YES	–
5.6	Invalid DLPDU	YES	–

Table 164 – CP 11/2: DLL protocol selection of Clause 6

Clause	Header	Presence	Constraints
6.1	General	YES	–
6.2	Synchronization DLPDU (SYN)	–	–
6.2.1	General	YES	–
6.2.2	Structure of SYN DLPDU	YES	–
6.2.3	Parameters of SYN DLPDU	–	–
6.2.3.1	Transmission permits node number (PN)	YES	Relevant feature to 100 Mbit/s operation of loop architecture
6.2.3.2	Control word (CW)	–	–
6.2.3.2.1	CW for star-architecture	NO	–
6.2.3.2.2	CW for loop-architecture	YES	–
6.2.3.3	Slot time (ST)	YES	Relevant feature to 100 Mbit/s operation of loop architecture
6.2.3.4	High-speed transmission period (Th)	YES	–
6.2.3.5	Medium-speed transmission period (Tm)	YES	–
6.2.3.6	Sporadic message transmission target-token-rotation-time period (Ts)	NO	Relevant feature to 100 Mbit/s operation of loop architecture
6.2.3.7	Low-speed transmission period (Tl)	NO	–
6.2.3.8	Live list (LL)	YES	–

Clause	Header	Presence	Constraints
6.2.4	User data	YES	–
6.2.5	Sending SYN DLPDU	YES	–
6.2.6	Receiving SYN DLPDU	YES	–
6.3	Transmission complete DLPDU (CMP)	YES	Relevant feature to 100 Mbit/s operation of loop architecture
6.4	In-ring request DLPDU (REQ)	–	–
6.4.1	General	YES	–
6.4.2	Structure of REQ DLPDU	YES	–
6.4.3	Node mode – ESYN Parameter	NO	–
6.4.4	Recipient node number (RN) Parameter	YES	–
6.4.5	User data of REQ DLPDU	YES	–
6.4.6	Sending REQ DLPDU	YES	Relevant feature to 100 Mbit/s operation of loop architecture
6.4.7	Receiving REQ DLPDU	YES	–
6.5	Claim DLPDU (CLM)	–	–
6.5.1	General	YES	–
6.5.2	Structure of CLM DLPDU	YES	–
6.5.3	Parameter of CLM DLPDU	–	–
6.5.3.1	Residual counts of CLM DLPDU parameter (RC)	YES	–
6.5.3.2	Slot time (ST) parameter	YES	Relevant feature to 100 Mbit/s operation of loop-architecture
6.5.3.3	Node mode (NM) parameter	NO	–
6.5.4	User data of CLM DLPDU	YES	–
6.5.5	Sending and receiving CLM DLPDU	YES	–
6.6	Command DLPDU (COM)	–	–
6.6.1	General	YES	–
6.6.2	Structure of COM DLPDU	YES	–
6.6.3	Parameters of COM DLPDU	YES	–
6.6.4	User data of COM DLPDU	YES	–
6.6.5	Sending and receiving COM DLPDU	YES	Relevant feature to 100 Mbit/s operation of loop-architecture
6.7	Cyclic data and cyclic data with transmission complete DLPDU (DT) and (DT-CMP)	–	–
6.7.1	General	YES	–
6.7.2	Structure of DT DLPDU	YES	–
6.7.3	Parameters of DT DLPDU	YES	–
6.7.3.1	DLCEP-address parameter	YES	–
6.7.3.2	Word length parameter (WD)	–	–
6.7.3.2.1	WD for star-architecture	NO	–
6.7.3.2.2	WD for loop-architecture	YES	Relevant feature to 100 Mbit/s operation of loop-architecture
6.7.4	Sending DT or DT-CMP DLPDU	YES	–
6.7.5	Receiving DT or DT-CMP DLPDU	YES	–
6.8	RAS DLPDU (RAS)	YES	–